OCCASIONAL PAPER 12

DEFINING A ROLE: 
THE EAL TEACHER IN MATHS

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June 1999

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NALDIC Publications Group. Series editors: Constant Leung and Deirdre Martin

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1. Introduction

EAL it seems, is always in crisis. Crises in funding, sources of funding, pedagogy, training, the National Curriculum, assessment, the literacy strategy – to name but a few – have kept EAL teachers feeling permanently under siege. Whilst no teacher of English, science, or art feels any pressure to justify the basis of their subject – its given place in the educational order of things – EAL teachers are still nervous that they are just one step away from vanishing from the landscape; subsumed by EMAG into the woodwork of that ill-defined – and therefore at risk – category of support staff. We – by which I mean teachers and researchers in the field – need to challenge and change this.

NALDIC News 16 (Nov. 1998), presented a set of competencies regarded as essential for EAL specialist teachers. This is an important part of the process of defining a clear identity and role within the education system. In the same issue, Amy Thompson forcefully argued that if the profession is to survive (let alone thrive) we must be able to demonstrate “the distinctiveness of EAL” as a discipline and the particular contribution that trained EAL teachers can make. I would argue that one fundamental way for us to demonstrate our distinctive role is by providing linguistically principled analyses of the register of the subjects we work with so that, in partnership, we can develop sound pedagogical and assessment practices that give our students access to the various discourse communities we seek for them to become effective members of and acquire English through. If we as practitioners do not know how the meanings of a particular subject are encoded in and developed through language, we will fail to make a distinctive contribution to scaffolding our students’ access to those meanings, and so be significantly less able to provide coherent and cohesive planning for their English language development. If we cannot do those things then we consign ourselves to a merely reactive, solely support role. If we take the initiative, however, we will be making a substantial contribution to teaching and learning in our multilingual schools.

2. Genre studies

Genre studies have provided us with the tools we need to make the sorts of analyses I am suggesting. There are a number of useful books on the subject (e.g. Swales, 1990; Hoey, 1991; Stubbs, 1996) but the field of genre studies in education has been most powerfully influenced by the work of the “Australian School” (Martin, 1985; Littlefair, 1991; Cope & Kalantzis, 1993; Halliday, 1994; Kress, 1994). My aim in this paper is to set out some of the possible features of this type of analysis in one particular content area, mathematics. Unlike science (see Lemke, 1990; Halliday & Martin, 1993, Martin & Veel, 1998), mathematics has been under-researched from this perspective, though some recent publications (Morgan, 1998; Solomon & O’Neill, 1998; Shield & Galbraith, 1998; Monaghan, 1999) suggest that
this situation is changing.¹

I will attempt to describe some of the main characteristics of the mathematics register in an English-speaking context. I will show how they can be applied at a general level to a set of curriculum resources; present an overview of more detailed linguistic aspects of mathematics and how they affect bilingual students’ learning of the subject; and outline some implications for classroom practice. In principle, I see no reason why my comments would not be equally pertinent to any other subject area and in reading this paper I invite you to reflect on how the issues I hope to raise might apply to your own particular field.

3. Literacy through the curriculum

Evidence in practice of one of the key competencies identified in the paper in NALDIC News requires that the specialist EAL teacher:

*analyses the language demands, needs and opportunities of the curriculum content and integrates language and content teaching matched with pupils’ needs.*

Whilst analysing and presenting the features of a specific register is likely to be a role of the researcher in applied linguistics, the analysis of how that register is reflected and developed in a particular syllabus is certainly one that a specialist EAL teacher should be equipped to conduct. If the EAL teacher is not able to track the development of the language through the particular syllabus they are engaging with, how is any effective language planning to occur? I am not arguing that we should be seeking to devise a precise language syllabus that maps structures, notions, functions or anything else against specific course units. This would first of all be a gigantic undertaking beyond the means of any individual or even language service; it would require a degree of training in applied linguistics for EAL teachers unlikely to be met by central government or local authorities; it would be entirely inappropriate for individualised schemes where the programme of instruction is tailored to each particular child’s needs; and it would anyway be akin to painting the Forth bridge - although given the history of the National Curriculum, when you got to one end of the bridge you would find they had started to rebuild it as a tunnel five miles downstream. That said, even in the absence of an ‘expert’ analysis of a particular register, any competent EAL specialist should be able to tackle the job of identifying the salient linguistic features of the courses they help deliver and to at least begin to track their development over time through the various units. Ideally, research and practice would combine, but in the absence of research there is a great deal that teachers can – and should – do themselves.

The following is based on work I carried out whilst working as an EAL teacher in mathematics. I undertook an analysis of the register of SMILE materials (Secondary Mathematics Individualised Learning Experience, an individualised scheme commonly used in London secondary schools and elsewhere). This involved creating an electronic database encompassing more than 90% of the available resources and using concordancing software to identify all occurrences of particular items in the scheme and display them in context. (There have recently been a number of useful books on this type of ‘corpus’ analysis, e.g., Sinclair,

¹ To judge by the requests for and responses to INSET sessions I have been invited to lead on the subject, there is a undoubtedly a genuine interest in and need for more work in this area.

1991; Thomas and Short, 1996). Clearly the level of analysis I describe here would be beyond the working resources of all but a very few EAL teachers. Nonetheless, the kinds of issues I examined would not be and could be usefully replicated on a smaller scale and extended year on year as part of an on-going process of curriculum development and partnership teaching.

3.1 The lexical level

I looked at the development of particular lexical items throughout the scheme. SMILE materials are organised and classified on the basis of mathematical attainment targets (for example, relating to number, shape, and data-handling) and by National Curriculum level. I was able to use the database and concordancing software to track, for example, all appearances of the lexeme ‘diagonal’ (including the forms diagonal, diagonals, and diagonally) and to examine them in context.

What this enabled me to do was to identify, explore, and exploit such matters as

- where the term first appeared in the scheme (i.e., NC level, enabling me to consider the match between the cognitive demand of the task and the language being used)
- in what mathematical contexts it appeared (solely relating to shape or other areas?)
- in what grammatical categories it appeared (as noun, adjective, and adverb)
- at what NC levels it appeared (allowing me to identify gaps and opportunities for further materials development)
- how its meaning was defined (or not)
- how its meaning(s) were developed (for example, I discovered that it was used in two ways: in its strictly mathematical sense as an attribute of shape and in its more everyday use as a synonym for any oblique line. I also discovered that it was the everyday meaning that was most prevalent, raising issues about how students develop the technical language of their subjects)
- how the meaning of the term changed ‘density’ as the cognitive demands increased (appearing at NC level 1 as a synonym for an oblique line in describing moves in a game with counters, and used at level 8 as a metaphor in a task on mathematical proof).

I was also able to examine a broader lexical field, in this case terms relating to angle, in the materials. Using this information it was possible to construct a number of tables to identify many of the features described above and others. For example, I was able to construct a table that displayed how frequently the term appeared in SMILE activities. An example of what this revealed was that the word scalene appeared only five times, as compared to isosceles, which appeared fourteen times and equilateral, which appeared twenty-four times. This might suggest gaps for possible supplementary materials. Teachers might also want to check whether this lack of frequency of occurrence in the materials is matched by a lack of frequency of recognition by their students. My own experience would suggest that this is the case. These are the sorts of insights into the curriculum that only a specifically linguistic investigation will reveal and would form part of the distinctive role of the EAL teacher.

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2 It was also carried out as part of my Ph.D. research project.
3.2 Definition systems

I was also able to explore broader aspects of the register, such as how the materials presented definitions. As SMILE materials have been created by many practising teachers over the last twenty-five years or so, there is no ‘house-style’ as might be imposed by a commercial publisher. I discovered some ten different ways in which definitions were presented:

- **Parentheses** - e.g., “... the same (invariant)”
- **Statement** - e.g., “... is called”; “means”, “is”
- **Paraphrase** - e.g., “in other words ...”
- **Upper case** - e.g., “the distance around or PERIMETER”
- **Inference** - e.g., “calculate the difference between the highest and lowest. Which has the biggest range?”
- **Etymology** - e.g., “p is the first letter of perimetron, which means perimeter”
- **Connectives** - e.g., “If you can draw the shape without going over any line more than once and without lifting your pencil off the paper then it is traversable”
- **Contrasting registers** - e.g., “You have probably seen a helix before but called it a spiral. In maths we only use the word ‘spiral’ for flat patterns.”
- **Physical activity** - e.g., carrying out a set of instructions followed by a statement such as, “this is a bisector”.
- **Diagram** - e.g., types of angle in a triangle.

What this illustrates, is the enormous variety of conventions that students need to become familiar with when engaging with text. If this many variations are found within a single aspect of a single subject area, what is the situation like across an entire curriculum? Students need to be made explicitly aware of how discourse elements are signaled and encoded in a text. In this case it was definition systems in maths but similar analyses could be applied to particular features in other subjects such as cause and effect in history, point of view in English, statements of hypothesis in science, etc.

3.3 Cultural aspects

Part of the role of the EAL teacher working in partnership with their mainstream colleagues, is to ensure that the curriculum is an inclusive one. As part of my study I examined how broader cultural aspects (such as ethnicity, gender, and disability) were reflected in the materials.
SMILE published its anti-racist policy in 1976 (see Alladina, 1985) and is committed to:

1. Teaching mathematics with a strong emphasis on its historical development, showing how at each stage mathematical developments have arisen as the response of different peoples to the problems they had to solve – be they Indian astronomers, Egyptian farmers, Spanish navigators or whoever.
2. Deliberately seeking out knowledge of the mathematics of the Third World Peoples and making it easily accessible to all children learning mathematics.
3. Making deliberate use of the different mathematical methods brought by children to the classroom – e.g. different counting systems.
4. Critically assessing the content of present mathematics from the point of view of its relevance to living in a multi-cultural society.

As part of my study, I explored whether these aims were reflected positively in the materials (happily, they are!). However, there is a tendency to identify the mathematics of “Third World Peoples” with cultural artifacts, e.g., Bangladeshi mathematics is reflected in the making of fans or fabric designs, or an activity based on Egyptian numbers is accompanied by an illustration of a pyramid and hieroglyphics, locating it firmly in the past. Nonetheless, the scheme does reflect an extremely broad range of contributions from other parts of the world; it presents Britain as a multicultural society, using names and images from many different cultural backgrounds; it uses children’s games from many different cultures; it presents mathematical and other artifacts from around the world; it includes internationally famous figures from mathematics and history; and promotes inclusive, collaborative learning strategies.

In terms of gender, it presents girls (from varying ethnic backgrounds) as active mathematicians and raises the profile of mathematics in everyday contexts (e.g., cooking and textiles) that are frequently dismissed as “girls’ stuff”. Equally, girls are presented positively in traditionally “boys’ stuff” areas such as logic, and in activities contextualised through sporting activities.

There is little explicit mention of class and the scheme would appear to fall into the common trap of locating lower levels of mathematics in settings associated with lower socio-economic status (e.g. simple addition in a down-market café), as discussed by Dowling (1994).

In terms of other social structures, the range of occupations is quite broad; familial relations, however, tend to be restricted to the ‘immediate’ family – SMILE has so far not made any explicit attempt to present positive (or indeed any) images of lesbian and gay people in its materials, for example. On the positive side, it has included at least one activity relating directly to disability, exploring issues relating to the needs of wheelchair users.

Clearly, such aspects are not confined to mathematics and an EAL teacher working in any content area should be seeking to analyse their current materials from these perspectives.

In the above section, I have tried to outline how an EAL teacher might play a distinctive role in terms of identifying and tracking some of the broader discourse features of a specific content area and how they might use that analysis to develop a more linguistically principled and inclusive curriculum. In the following section I would like to provide a more narrowly focused discussion of the mathematics register that might assist consideration of how analysis...
of the way the language is structured might be used to support students engaging with the concepts embedded within and through that structure.

4. The register of mathematics

Mathematics is not a discrete language in the sense that, say, English or Bengali are. There is no group of people for whom mathematics is a native language (though your schooling may have left you feeling there was!). Mathematics is better regarded as a language in a metaphorical sense and, for the purpose of analysis, as a particular register as defined by Halliday (1978: 195):

A register is a set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings. We can refer to a mathematics register in the sense of the meanings that belong to the language of mathematics (the mathematical use of natural language, that is not mathematics itself), and that a language must express if it is being used for mathematical purposes.

In this section of the paper I am going to discuss the “words and structures” of the mathematics register.

4.1 Vocabulary

Essentially, there are three types of vocabulary to be found in mathematics:

1) General – chair, bath, water, etc.
2) Technical – trigonometry, rhombus, algebra, etc.
3) Specialist – point, similar, difference etc.

To this list I would add a fourth type, which has been shown to have a particular impact on bilingual learners’ in mathematics, and that is:

4) Discoursal - e.g., logical connectors (therefore, because, and, etc.)

4.1.1 General vocabulary

Inevitably, much of the vocabulary found in a mathematics course will be everyday vocabulary with no specifically mathematical meaning. Earp and Tanner (1980) analysed an American sixth grade text book and found that non-mathematics words had a comprehension accuracy of 98 per cent, compared with only 50 per cent for the mathematics words.

It would appear to make sound pedagogical sense, therefore, to draw heavily on language that is as supportive of comprehension as possible and so it is not surprising that word problems draw heavily on ‘ordinary’ English as in the following example:

1. Between 7 p.m. and 7.30 p.m. at the chip shop:
   27 customers bought fish,
   53 customers bought chips.
   Only 60 people were served.
   How many ordered both fish and chips?
The assumption is that ordinary English will be 'easier' for pupils to process than mathematical English and so the language will not obstruct the pupil in solving the problem. By giving a specific real world context (the chip shop) the pupil should be better able to solve the problem than if the pupil were given a purely mathematical context. The problem could, for example, be represented as follows:

\[
\begin{align*}
\text{A} & \quad \text{B} \\
\text{n}(A) = 27 \\
\text{n}(B) = 53 \\
\text{n}(\emptyset) = 60
\end{align*}
\]

Find \( n(A \cap B) \).

In order to understand this representation the pupil must be familiar with Venn diagrams, set notation, and the concepts of intersection and the universal set. By using general vocabulary, the student can still demonstrate underlying mathematical abilities which might otherwise go unnoticed due to unfamiliarity with the mathematics register.

This is not to argue, of course, that the general vocabulary would suffice and that the specialised language of mathematics is redundant. There is a danger in attempting to avoid mathematical language, which has its particular advantages of precision. For bilingual students – especially those whose educational background has included formal mathematical notation as above – it may actually be the 'everyday' language that is the obstacle; the contextualisation of the problem may not tally with any schema the child is familiar with, or may contain unfamiliar vocabulary. The issue is not a simple one and the EAL teacher should have the expertise to help unpick it.

4.1.2 Technical vocabulary

Mathematics, like any specialist field of academic study, has a rich and sometimes mysterious vocabulary of its own. To insiders, such vocabulary aids the concise and precise formulation and communication of ideas. To outsiders it can appear arcane and block understanding. This may be particularly the case in mathematics where much of the terminology is Greek or Latin in origin which, as Corson (1985) has argued, may present a “lexical bar” to certain groups of students, preventing them from gaining access to higher levels of academic achievement. For some bilingual students however – from Romance languages backgrounds for example – such terms may be familiar as cognates. Clearly, course designers and teachers need to be sensitive to the appropriate introduction and development of mathematical vocabulary if students are not to be handicapped.
4.1.3 Specialist vocabulary

The third type of vocabulary covers those words which are found in the general vocabulary but which also have particular mathematical meanings, such as *similar* or *difference*.

When children are asked questions such as “What is the difference between 12 and 7?” they might (and in my experience commonly do) respond that one is an even number and the other odd; that one is a single digit number and the other a two digit number; that one is a prime number and the other is not, etc. Halliday (1975) has pointed out that the difficulty does not only arise at the individual word level but also with larger units, *e.g.*, *least common multiple*, a conceptually complex unit of meaning requiring the students to synthesize its three separate elements. A common example of this is the frequent mistake pupils make when first introduced to the concept of right-angled triangles; they will often generate the existence of left- or even wrong-angled triangles! Orton (1987: 127) also discusses this problem and argues:

> It is very questionable whether more than just a small minority of our pupils ever distinguish the mathematical meaning of ‘similar’ from its everyday meaning. The particular problem here is that the two meanings are not far apart, the distinction is quite a subtle one. ... Clearly, it is very important, when a word like ‘root’ is introduced in a mathematical lesson, that the pupils are given the opportunity to come to terms with the particular mathematical meaning.

It is important to recognize that the confusion does not reside in the words or symbols themselves, but in understanding “the particular mathematical meaning” they are used to signify in particular contexts. As the UNESCO report (1970: 93) points out, speakers are generally able to identify the context in which a word is being used and so, ultimately, the issue is conceptual understanding:

> Once the concept is clearly perceived, which word is attached to it is of minor importance, even when that word already has a different significance in a different register.

Perception of primary meaning rather than mathematical meaning gives the teacher an opportunity to make a strong inference about the student’s grasp of the concept and can provide teachers and students with extremely useful insights into their learning. There is a clear role here for EAL teachers in scaffolding content/language learning contexts that ensure and enmesh both the cognitive and linguistic development of their pupils.

4.1.4 Discoursal vocabulary

Most discussions of vocabulary tend to focus on lexical items. Carter (1987: 35), for example, whilst recognising the importance of discoursal words, limits his discussion of ‘core’ vocabulary to “lexical words” (nouns, verbs, etc.). A particular feature of the mathematics register is the significance of discoursal words (e.g. logical connectives such as *therefore, unless*, prepositions, and question words). Discoursal words tend to be more difficult for second language learners to acquire (Carrell, Devine, Eskey, 1988) – perhaps because of a general lack of focus on them both in the literature and the classroom. It is
therefore not surprising that their particular uses in a specialist register such as mathematics has been found to cause particular difficulties for bilingual students.

Dawe (1983: 348), for example, found in his study of bilingualism and mathematical reasoning in English as a second language, that knowledge of logical connectives was the single most discriminating variable on a test of deductive reasoning “accounting for one third of the variance”. He concludes that:

... the development of the ability to use logical connectives for reasoning and argument is an important task for mathematics and science teachers.

It is important to note that Dawe found that the results were consistent for both L1 and L2 speakers of English. As so often with EAL input, materials targeted at improving students’ understanding of the role of logical connectors are likely to benefit all learners in the classroom.

It is not only the presence of unfamiliar vocabulary, or familiar vocabulary used in new ways, that is important to the student’s development of the mathematics register. As Halliday (1975: 66) points out:

Registers such as those of mathematics ... also involve new styles of meanings, ways of developing an argument, and of combining existing elements into new combinations.

A central role in such “combinations” is, of course, played by syntax.

4.2 Syntax

Halliday (1978: 195) rightly reminds us that, “We should not think of a mathematical register as consisting solely of terminology.” (This applies equally well to any other specialist subject, of course.) Linville (1978), argues that syntax difficulties can be as important as vocabulary problems. For example, in ordinary English, 8 divided into 2 is 4 but in mathematical English it is 1/4 (a quarter). A similar example is cited by Pimm (1987: 20), commenting on the common erroneous expansion of (a+b)^2 as a^2+b^2 (rather than the correct a^2 + b^2 + 2ab).

Other syntactic features of the mathematics register that may be unfamiliar to students include the fact that there is no automatic plural agreement, for example, it is correct to say 3/7 is greater than 2/7 since 3/7 is a single number. Items can change grammatical class in mathematical English; for example, numbers can be both adjectives, (3 books), or nouns with properties (3 is a prime number). Certain features are more pervasive in the mathematics register; for example, gerunds (addend, integrand, multiplicand), passives (Successive terms in a Fibonacci sequence are found by adding the two previous terms, and imperatives (let, define, draw, etc.). All of these syntactic features may cause difficulties for any student who is unfamiliar with the peculiarities of mathematical English. Bilingual learners have been shown to experience particular difficulties with certain syntactic features of the register. For example, Jones (1982) found that pupils in Papua New Guinea had problems with more and less distinctions and Dawe (1983) reported that native Australian students had particular problems with logical connectives, such as if...then clauses.
4.3 Symbols

Perhaps the most immediately striking difference between ordinary English and mathematical English is the use of symbols. As the Association of Mathematics Teachers point out (ATM, 1983: 18):

Because mathematics provides its own context, and because the structures involved soon become too complex to hold in the mind, mathematising can only develop beyond a simple level if it is mediated by signs.

Clearly, a great deal of information can be compressed into a single symbol – and indeed must be – to allow routine manipulation to become automatic and so free attention for the creation of more extended meanings. Nonetheless, such conciseness can come at the cost of comprehensibility. Students need to be made explicitly aware of the meanings attached to symbols. Kane et al. (1974) discovered that 90 per cent of 7th and 8th graders in the United States knew only +, -, x, ÷, $, c, and the numerals.

Mathematics uses a wide variety of symbols; the following is a description of the main types of symbols found in the register.

Logograms are specially invented symbols such as = or £, which, like symbols in other registers, have their own etymologies; the £ sign for example is a modification of the letter ‘L’, the first letter of the Latin ‘librum’ from which English ‘pound’ derives.

Pictograms such as Σ. Pictograms have the advantage of immediate recognisability, though some can be less clearly pictogrammatic than others!

Punctuation. A wide variety of standard punctuation symbols are used with specifically mathematical meanings. For example, simple brackets may be used, amongst other things, to identify which operations in an equation are carried out first: (2x3) − 2 = 4 or to denote co-ordinates: Oxford Circus station is at (G,7) on the Underground map.

Alphabetic symbols are also frequently used; mainly Roman and Greek, though some Hebrew symbols are used in the description of infinite sets.

Symbols, like other linguistic tokens, also have systematic features. Order is significant, for example 17 has a different meaning to 71. Position likewise affects meaning, 32 is not the same value as 23. Orientation also determines meaning, just as ordinary English has ‘d’ and ‘p’, mathematics has ‘+’ and ‘×’ and ‘>’ and ‘<’.

What is evident from the above, then, is that mathematical English behaves like ordinary English in exploiting features of the language system to create its own meanings. It does so in its own particular way, however. A potential problem with this natural behaviour lies in the differences between the two registers’ use of similar features and the possible interference from one to the other. For example, students unaware of the fact that where numbers are combined with letters – as in algebraic expressions such as 3a= 5b – the implied operation is multiplication. Students frequently have difficulty in understanding that 3a denotes a completely different relationship between the two elements than, say, 34.
4.4 Metaphor

The pervasive role of metaphor throughout every area of language use has been well documented in such collections as Ortony’s “Metaphor and Thought” (1979). Mathematics is no exception to this in spite of a common misconception that the language of mathematics is extremely precise and objective. As Halliday (1978: 202) argues:

... it would be a mistake to suppose that the language of mathematics ... is entirely impersonal, formal and exact. On the contrary, it has a great deal of metaphor and even poetry in it ...

Metaphors can cause problems too, however. Consider, for example, a common metaphor for subtraction, that of taking away. There is a carry-over between the semantic field and the lexical structure which can lead to misconceptions. By coming to equate taking away with numbers getting smaller, pupils find it difficult to accept such statements as $2 - 2 = 4$ as true. The same confusion arises in the conception of multiplication as making numbers bigger, when confronted with statements such as $1/2 \times 1/3 = 1/6$. Such confusion does not only arise at the operational level of arithmetic but also in perceptions of particular forms of representation.

Graphs, for example, are often presented to pupils as ‘drawings’. This can lead to misinterpretations of time-distance graphs such as the following:

![Graph](image)

Kerslake (1982: 72) reports that students responded to the question, “What’s happening here?”, by treating the graph as a narrative illustration and replied:

| C1 | You’re going N.E., then S.E. and then N.W. |
| C2 | You’re going up a mountain, say, and then coming down a bit, and going up again. |
| C3 | It’s going along, then turning right and then turning left. |

Such potential ambiguities can be deliberately exploited to check for understanding and make students explicitly conscious of the limits of the ‘drawing’ metaphor.
4.5 Semantics

Pimm (1987: 175) has argued that:

... school teaching at all levels seems to have accepted the goal of symbolic algorithmic fluency without sufficient concern for semantic re-integration.

As an example of this he cites the confusion of sign (how something is presented) and referent (what it represents) that arises out of unqualified uses of language. For example, a sentence such as 17 is a prime number is true in base 10 but not in base 8 (where it would be equivalent to 15). The use of base 10 as the ‘default’ leads to the confusion of the particular sign 17 with its numerical properties. This semantic confusion can spill over into rules such as to divide by a fraction, invert and multiply which seek to explain numerical operations as mere manipulations of the symbols. Unless ‘semantic re-integration’ occurs children may be able to do mathematics but they are unlikely to understand it. When working with a child on a problem, EAL teachers need to be aware of, and resist, their own ‘training’ in mathematics, which is likely to have been based on such ‘rule-governed behaviours’!

These features are, of course, combined in particular ways to produce mathematical texts and, inevitably, the whole is greater than the sum of the parts. In the following section I will describe what students face when trying to solve this particular ‘sum’ when reading and writing mathematics.

5. Reading and writing mathematics

“Success in learning mathematics depends to a large extent on success in reading” (Earle, 1976). Mathematical writing draws on a wide range of text types and students need to be familiar with their conventions. A typical text will contain: expository writing; instructions; exercises; peripheral writing designed to engage the reader’s interest and motivate them to continue reading; signals of various kinds to indicate what to do next; and a wide variety of graphics such as tables; diagrams; graphs; histograms, etc. The following illustrate some distinctive aspects of mathematics texts, aspects which the students must control if they are to be effective readers and writers of the subject:

- The context is less rich than that of ordinary English. It is intolerant of ambiguity and exhibits less redundancy. For example, in a storybook the illustrations may largely function as an additional aid extending understanding (see Kress and Leuwen, 1997), whereas in a mathematics text they are central to it.

- Many of the conventions of reading an English text are not applicable to reading in mathematics. Left-right/top-bottom processing does not hold. Reading is frequently non-linear, as when students are required to refer back and forth to tables or to interrupt reading in order to fetch equipment or use calculators to carry out calculations.

- Similar combinations of elements do not necessarily imply identical operations. For example 34 = (3 x 10) + 4, whereas 3a = 3 x a. The reading of symbols also demands
different processing skills. Whilst there are one-to-one equivalencies (such as ‘+’ meaning ‘plus’) there are no obvious verbal equivalents to the use of brackets as in, say, $(2 \times 3) - (5 + 2)$. As we have seen, spatial arrangements also carry meaning, so that $2^3$ is not the same as 23.

- **Logical connectives**, as previously discussed, have a significant impact in terms of bilingual students’ reading. Cohen et al. (1984: 101) found that L2 students had particular difficulties with cohesive ties in texts and reported this aspect as a source of difference in performance between L1 and L2 speakers:

  The nonnatives, unlike the natives, ... did not organize the material that they had read when that organization stretched across different paragraphs, although cross-paragraph markers of cohesion were provided in the text.

The problem of L2 students tending to read more ‘locally’ than more proficient readers (i.e. at the sentence level rather than at the larger discourse level) has also been commented on by Carrell et al. (1988). In mathematics texts, the problem can be further exacerbated by students tracking reference through cohesive ties such as logical connectives and having to cope not only with written text but also symbols, tables or other graphics that interrupt that text.

When students come to write mathematical texts of their own (especially extended pieces such as investigative tasks) they need to be explicitly aware of such distinctive genre features and incorporate them in their own work. Whilst some writers (e.g., Countryman, 1992; Burton, 1996) extol the virtues of recount styles of writing in mathematics, advocating the use of journals and autobiography, there are others who warn strongly against them (Marks & Mousley, 1990; Morgan, 1998; Solomon & O’Neill, 1998). In my view, literacy in mathematics involves expressing mathematical meanings through mathematical means. The relationship of a genre’s form to its content is not merely fortuitous; it has evolved as a result of the practice of members of a particular discourse community finding appropriate forms to develop and communicate their knowledge. This is as true of mathematics (which as Solomon & O’Neill show was once conducted through recount genres and even poetry) as it is of science or history. This is not to ignore or diminish the potential value of other genres but at the same time priorities need to be set for how our time is spent and on what. It is a proper task for EAL teachers to ensure that bilingual students are enabled to enter the discourse community of mathematics by being schooled in the particular forms of literacy it has developed. The EAL teacher needs to work in partnership with their colleagues in mathematics to identify the types, purposes, and conventions of written mathematics and to plan for their development within the syllabus.3

6. Materials Design

Analysis is one thing, classroom practice another. It is important to demonstrate how the

3 At North Westminster Community School I was very fortunate to work with an outstanding maths department who embraced this initiative and even went on to formulate their own non-narrative writing policy for mathematics.

above analyses can lead to concrete results. There is insufficient space in this paper to do any more in the following section than provide a few indicative examples and discussion of materials designed to fulfill three particular purposes in the mathematics classroom: developing appropriate resources for the initial assessment of bilingual students; creating materials that foster the combination of both language and content; and the use of writing frames to develop more extended writing in mathematics.

6.1 Initial assessment

In summative forms of assessment, students can often be tested at least as much on their language skills as their content knowledge. This is particularly true of bilingual learners and may lead to under-assessment of their abilities. When such a child joins the class it is important to assess their competence in both areas. The activities below were developed so that teachers could gain some formative insight into their students’ understanding of mathematical language, which would help them gain a more rounded picture of their abilities. The intention is that they be used to complement the ‘normal’ forms of assessment that the teacher would draw on.

The focus in the following examples is on student’s knowledge of the language of mathematics and their reading skills, not on their ability to find the answer. In the example ‘2.2’, for example, visual support is provided to contextualise the situation. In the second question, the teacher may discover whether the child understands the word ‘total’ or, failing that, whether they know that when reading an unknown word a good strategy is to carry on and see if the meaning is still accessible - as it probably is here. In ‘2.3’ there is an evident focus on synonyms for addition and ‘2.6’ might offer some insights into the student’s awareness of shape attributes (length and width) and how they are commonly assigned (the longer side is the length, the shorter side the width.).
2.2 Money

Menu

- Pizza 75p
- Hamburger 69p
- Hot-dog 49p
- Ice-cream 35p
- Coffee 42p
- Canned drinks 37p
- Milkshake 60p
- Milk 22p

What does a hamburger cost?
What is the total cost of a hot-dog and milk?
How much is an ice-cream and a coffee?
How much is pizza, a canned drink, and a milkshake altogether?
I buy a hamburger and milk. What change do I get from £1.

2.3 Addition/subtraction

What is
2 plus 3, 5 minus 2
4 and 6, 5 add 3
7 take away 3
6 subtract 2
The sum of 4 and 4

2.6 Measurement

How long is this rectangle?
How wide is this rectangle?
What is the length of the rectangle?
What is the width of the rectangle?

In the following example, the student is similarly required to identify and check the meaning of particular mathematical terms:
Similar activities were developed to explore other aspects of mathematics, such as knowledge of types of numbers, e.g. odd, even, prime, square, etc.

6.2 Language and content

Using the insights gained from the genre studies approach, it becomes possible to develop materials that bring together the language and content of mathematics.

In the following activity, for example, it is impossible to get the right answer and complete the task without understanding and deploying particular features of the mathematics register. Students are at once provided with and expected to make sense and use of a specifically mathematical genre (the pie chart) and the language associated with it. Only a close reading of all aspects of such a diagram, (the title, legend, pie, and data) will provide students with the correct solution. The writing task is structured as a straightforward gap-fill with a simple sentence structure modeled in the example. It also makes explicit the elements of a specifically mathematical form of visual presentation, deploys a common mathematical method of proof by elimination and gives practice in using a logical connective (because), which bilingual students have been shown to have difficulties in using. As such, the activity represents a sound marriage of language and content and scaffolds the student's engagement with both.
6.3 Writing frames in mathematics

Maureen Lewis and David Wray have written extensively on the development of students’ non-fiction writing (Lewis & Wray, 1995; 1997) and their work on writing frames (1998) has had a considerable appeal for EAL teachers. In this book, they provide a number of sample frames from various curriculum areas, including mathematics. These provide an extremely useful starting point but are limited to “investigative” work and there is a need for other models to develop specifically mathematical modes of writing, as in the following example:
Properties of shapes

I am going to compare a _________ and a _________.

A _________ looks like this (sketch):

A _________ looks like this (sketch):

A _________ has ________________ .

A _________ has ________________ .

A _________ has ________________ .

A _________ has ________________ .

\[\therefore\] they are the same in that they both have ________________ .

The difference between a _________ and a _________ is that ________________ .

\[\therefore\] means: therefore

NB: the mathematical symbol \[\therefore\] means: therefore

This frame is ‘mathematical’ in that it exploits and requires the student to make use of particular features of the register such as the use of diagrams, line-by-line argument, symbols, and logical connectives.
In summary

The mathematics register, whilst sharing many of the features of ordinary English, has conventions of its own which students need to be made explicitly aware of. Halliday (1978: 203-204) has pointed out that, teachers of mathematics, in particular have emphasised the importance of learning through concrete operations. He goes on to argue that whilst this is a positive step, it is not an argument for seeking to eliminate language from the process of learning mathematics. Instead, he argues:

Rather than engage in any such vain attempt, we should seek equally positive ways of advancing those aspects of the learning process which are, essentially, linguistic. We need not deplore the tendency of language to impose patterns and values on reality; on the contrary, it is a tendency that a learner can put to his advantage, once he, and his teachers, are aware of how language functions ... in these respects.

Just as the mainstream colleague’s training equips them to weave the strands of their specialism into a well-constructed conceptual network so ought the EAL teacher be particularly well placed and equipped to map out the essential linguistic features and patterning of the registers of the subjects they support. Only when these two matrices are combined – the concepts and language they are represented through – can we really begin to make sense of the patterns, meanings, and values they construct. And only in so doing, can we begin to envisage providing a coherent and cohesive language development programme for our students. If we can’t do that then how do we define a distinctive role?
References


